

Assimilation of Quality Controlled AIRS Version 5 Temperature Soundings

Joel Susskind

GSFC Sounder Research Team

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Objectives of AIRS/AMSU

Provide real time observations to improve numerical weather prediction

Could be \hat{R}_i (used by NCEP, ECMWF) or $T(p)$, $q(p)$

Accuracy of \hat{R}_i , $T(p)$, $q(p)$ degrades slowly with increasing cloud fraction

There is a trade-off between accuracy and spatial coverage

Using soundings or radiances only in clear cases limits utility of the data

Provide observations to measure and explain interannual variability and trends

Must provide good spatial coverage but also be unbiased

Can be less accurate than needed for data assimilation

Must not contain systematic data gaps in certain regions

Error estimates and quality flags provide options for use in either weather or climate applications

Version 5 quality flags are based on fixed error estimate thresholds

The user can assign different quality flags as they see fit

Generation of Empirical Error Estimates δX_i

This step is done after physical retrieval is otherwise completed

Methodology used for δSST , $\delta T(p)$, $\delta W_{\text{tot}} / W_{\text{tot}}$ is identical

Uses 16 internally computed values of convergence tests Y_j

δX_i , error estimate for X_i is computed according to

$$\delta X_i = \sum M_{ij} Y_j$$

Determination of M_{ij}

Use profiles with “truth”

$$\Delta X_i = |X_i - X_i^{\text{TRUTH}}|$$

Each profile now has ΔX_i , Y_j

M_{ij} found which minimizes RMS $|\delta X_i - \Delta X_i|$

M_{ij} generated using all September 29, 2004 cases in which IR retrieval is accepted

ECMWF taken as “truth” to provide ΔX_i

M_{ij} tested on January 25, 2003 - used once and for all

Same basic approach is used for $\delta \hat{R}_i, \delta q(p)$

Methodology Used for V5 Quality Control

Temperature Profile $T(p)$

Define a profile dependent pressure, p_g , above which the temperature profile is flagged as good - otherwise flagged as bad

Use error estimate $\delta T(p)$ to determine p_g

Start from 70 mb and set p_g to be the pressure at the first level below which

$\delta T(p) > \text{threshold } \delta T(p) \text{ for } n \text{ (currently } = 3 \text{) consecutive layers}$

Temperature profile statistics include errors of $T(p)$ down to $p = p_g$

Sea surface temperature SST

Flag SST as good if $\delta \text{SST} < 1.0\text{K}$

Total precipitable water W_{tot}

Flag W_{tot} as good if $\delta W_{\text{tot}} / W_{\text{tot}} < 0.35$

Clear column radiance \hat{R}_i

Flag \hat{R}_i as good if $\delta \hat{R}_i < 0.9\text{K}$ in brightness temperature error units

Thresholds for $T(p)$ - Computation of p_g

p_g is the highest pressure at which $\delta T(p) > DT(p)$ for 3 consecutive levels

$DT(p)$ is defined at 3 pressures: $DT(70 \text{ mb})$, $DT(p_{\text{surf}}/2)$, and $DT(p_{\text{surf}})$

$DT(p)$ is linearly interpolated in $\ln p$ between these 3 values

Separate values for $DT(p)$ are specified for non-frozen ocean and for land/ice

Version 5 uses Standard thresholds optimized for weather and climate simultaneously

We have done forecast impact experiments with other thresholds: Medium and Tight

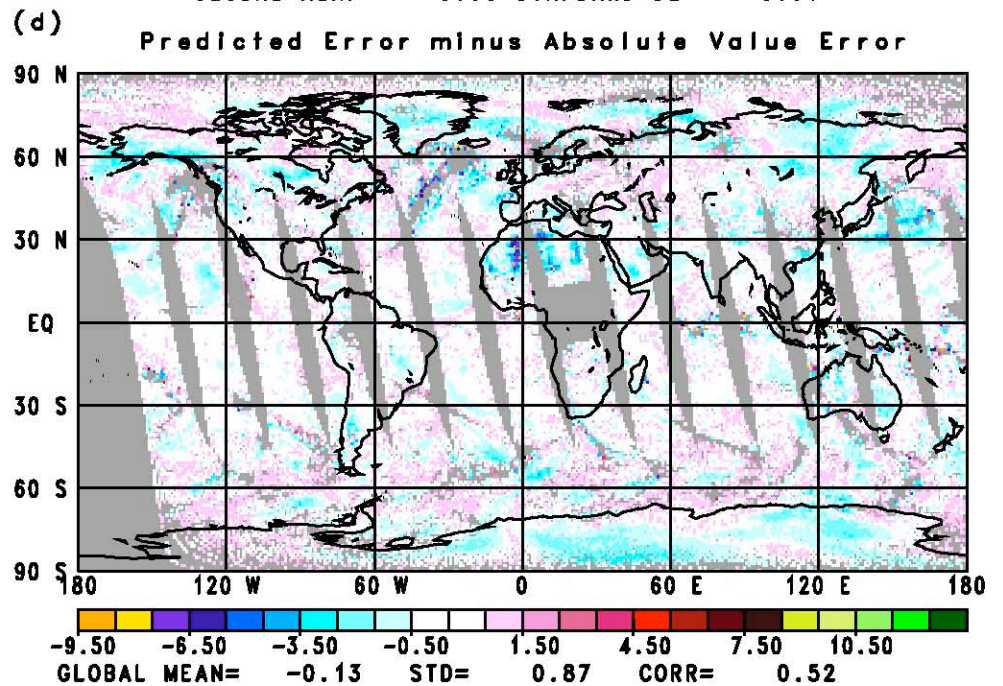
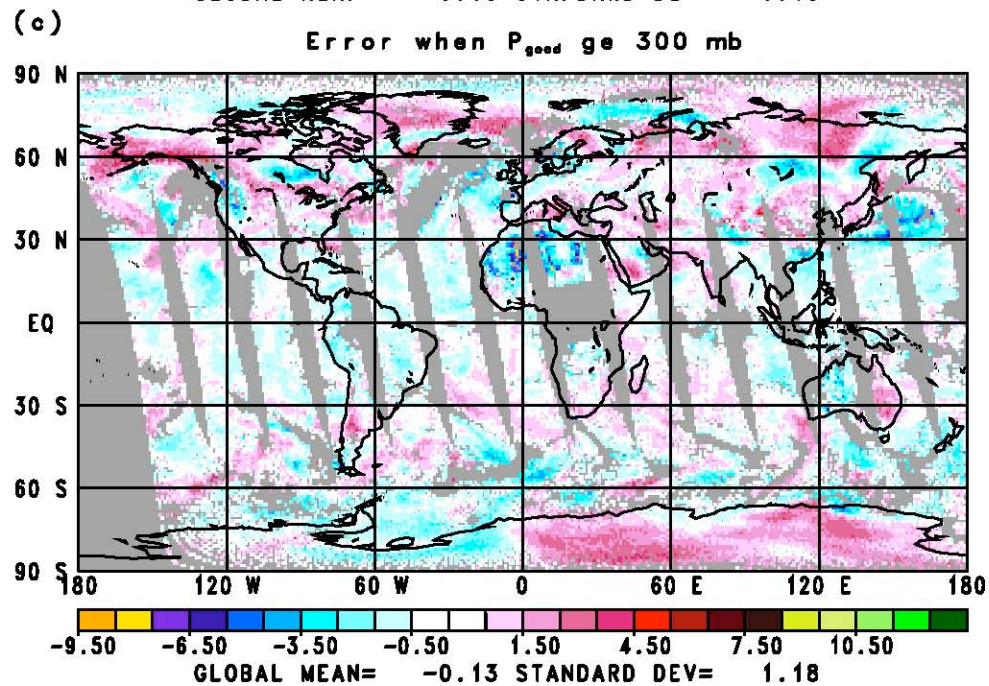
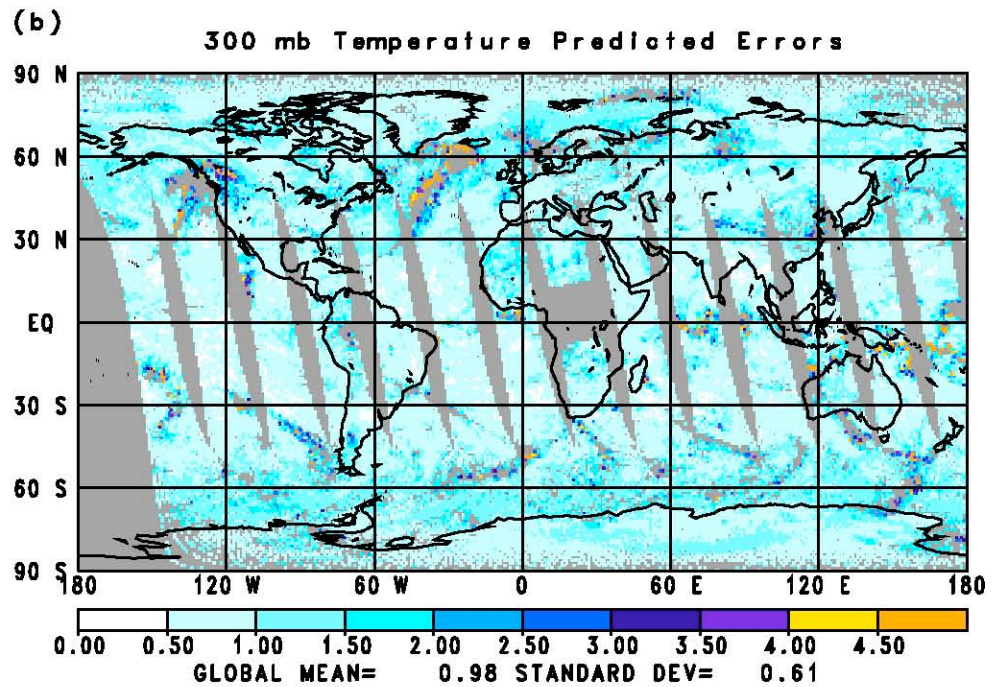
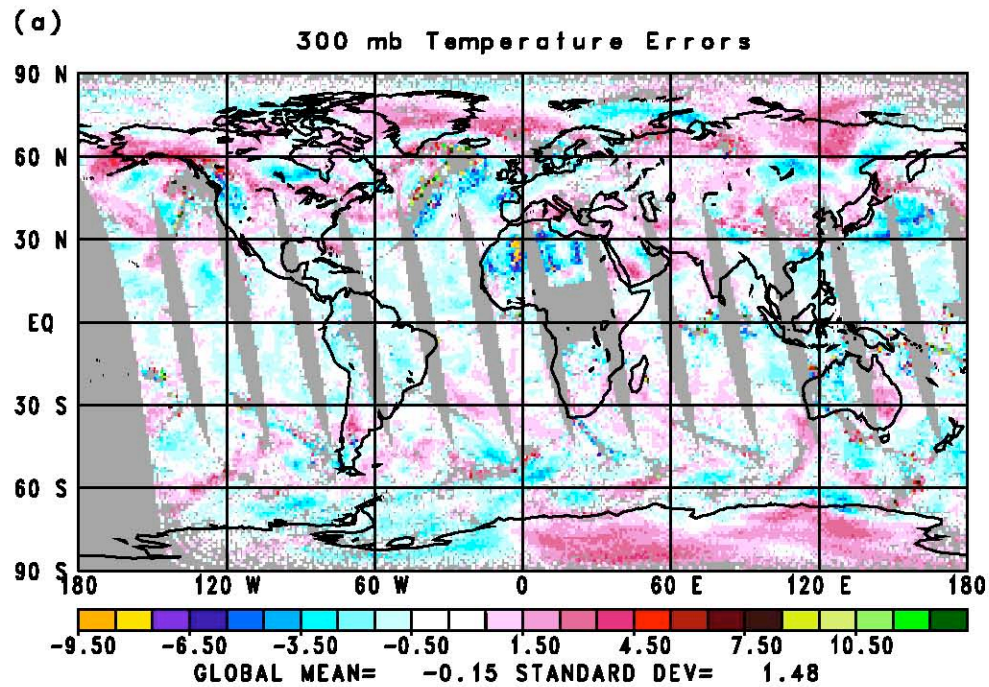
Purpose is to assess trade-off between spatial coverage and accuracy

Table 1

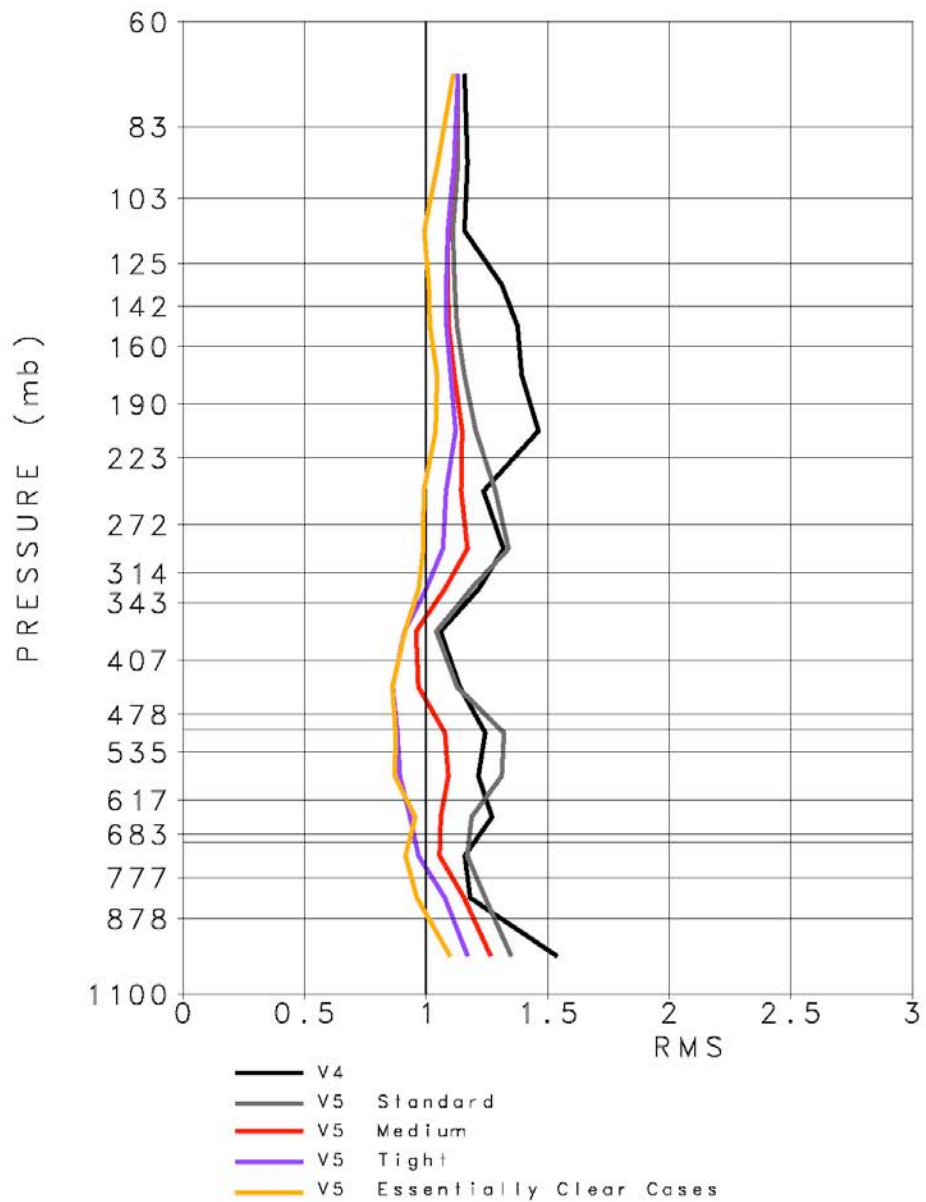
Temperature Profile Thresholds (K)

	Ocean			Land/Ice		
	$DT(70 \text{ mb})$	$DT(p_{\text{surf}}/2)$	$DT(p_{\text{surf}})$	$DT(70 \text{ mb})$	$DT(p_{\text{surf}}/2)$	$DT(p_{\text{surf}})$
Standard	1.75	1.25	2.25	2.25	2.0	2.0
Medium	1.75	1.0	1.75	1.75	1.0	2.0
Tight	1.75	0.75	1.75	1.75	0.75	1.75

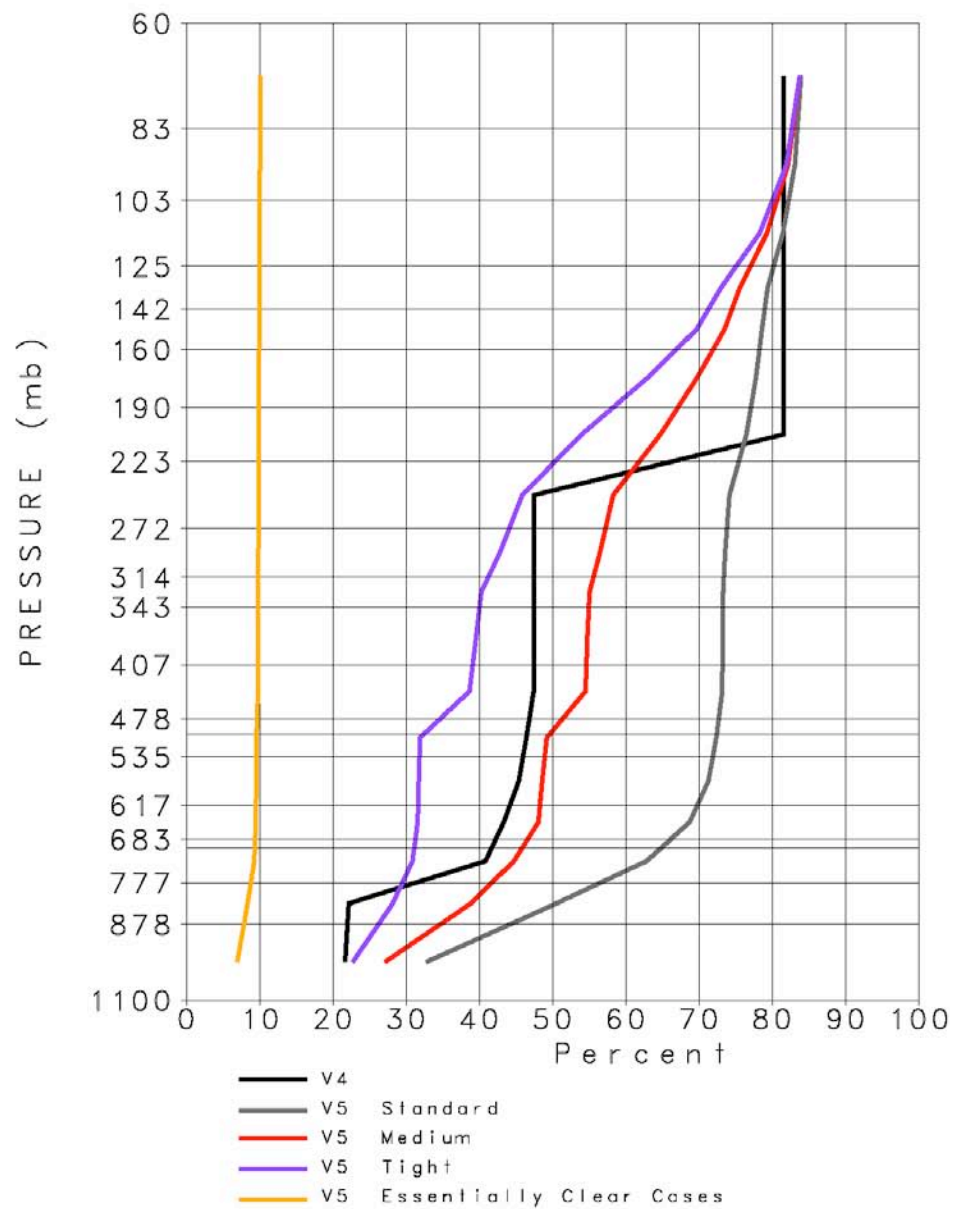
300 mb Temperature (K) Retrieved minus ECMWF January 25, 2003 V5



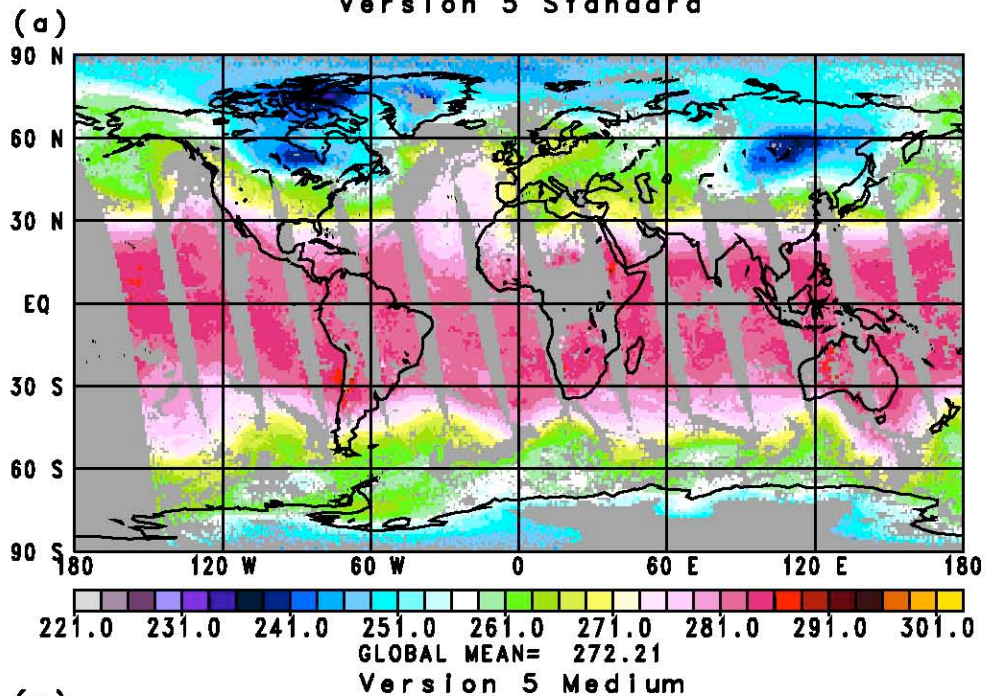
LAYER MEAN RMS TEMPERATURE ($^{\circ}\text{C}$)
GLOBAL DIFFERENCES FROM ECMWF
January 25, 2003
Global



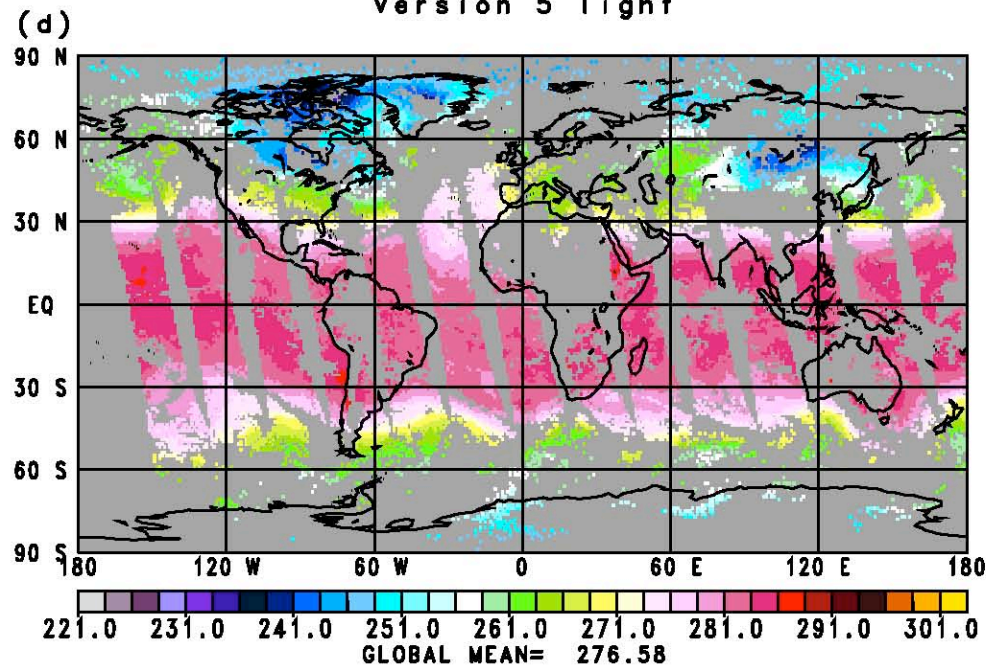
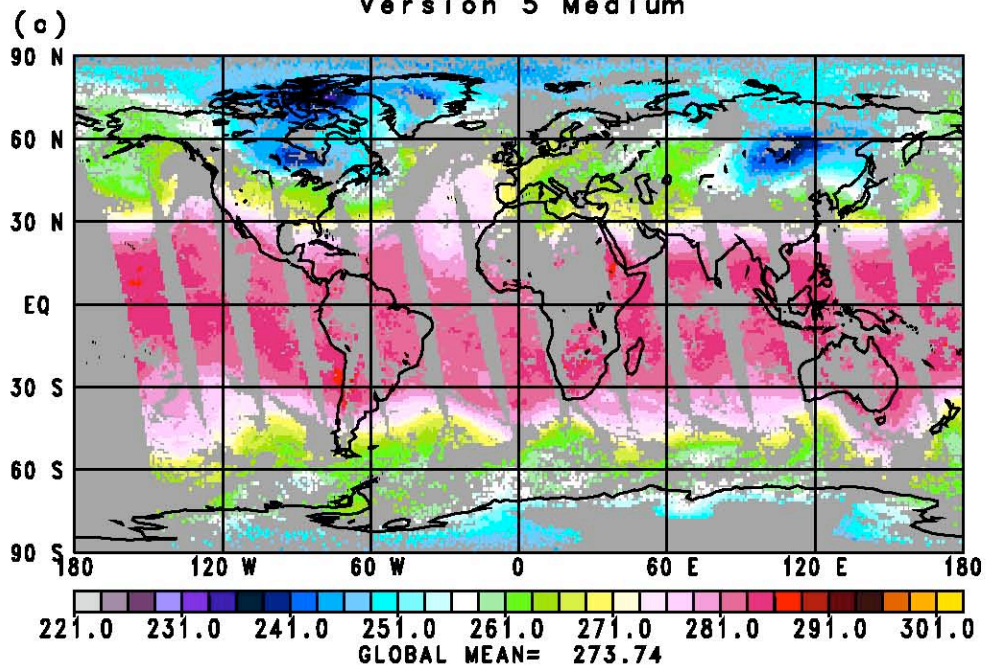
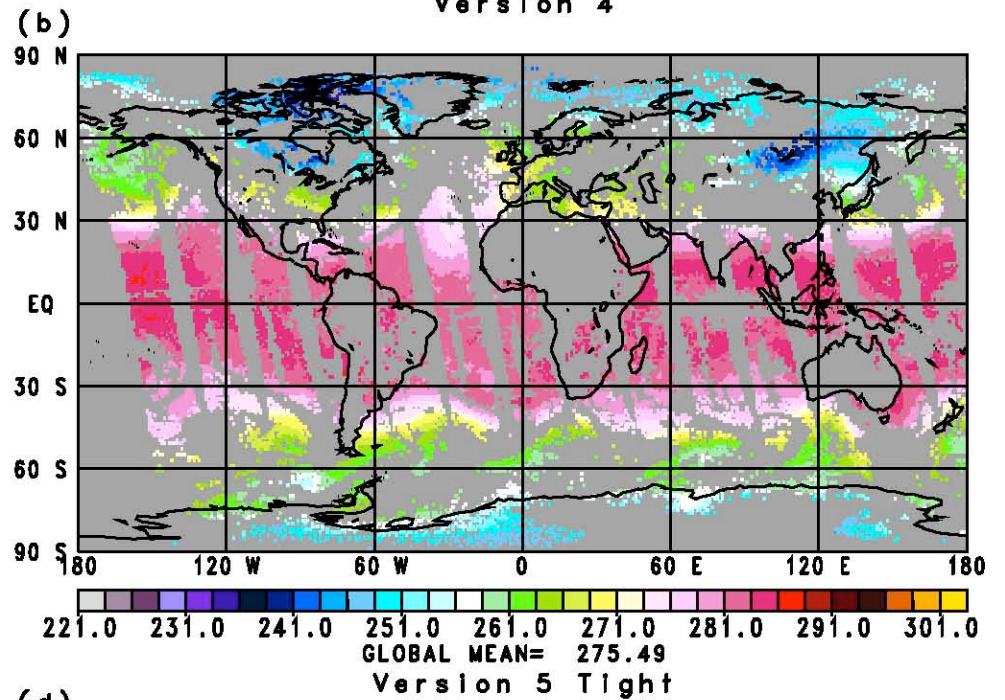
Percent of IR/MW Cases Included
January 25, 2003
Global



700 mb Temperature Version 5 Standard



January 25, 2003 Version 4



Forecast Impact Test

Experiments run with GSFC GEOS-5 data assimilation system

Forecasts run at $1^\circ \times 1^\circ$ resolution

Analysis using NCEP GSI analysis at $1^\circ \times 1^\circ$ resolution

Data period covers January 1, 2003 - January 31, 2003

Control uses all data NCEP used operationally at that time

Assimilates all satellite data but AIRS, including Aqua AMSU radiances

Control + AIRS adds V5.0 global quality controlled T(p) retrievals

Assimilated as if radiosonde data

$\delta T(p)$ is used as the measurement error

27 independent forecasts run from each analysis

Forecasts verified against NCEP analysis

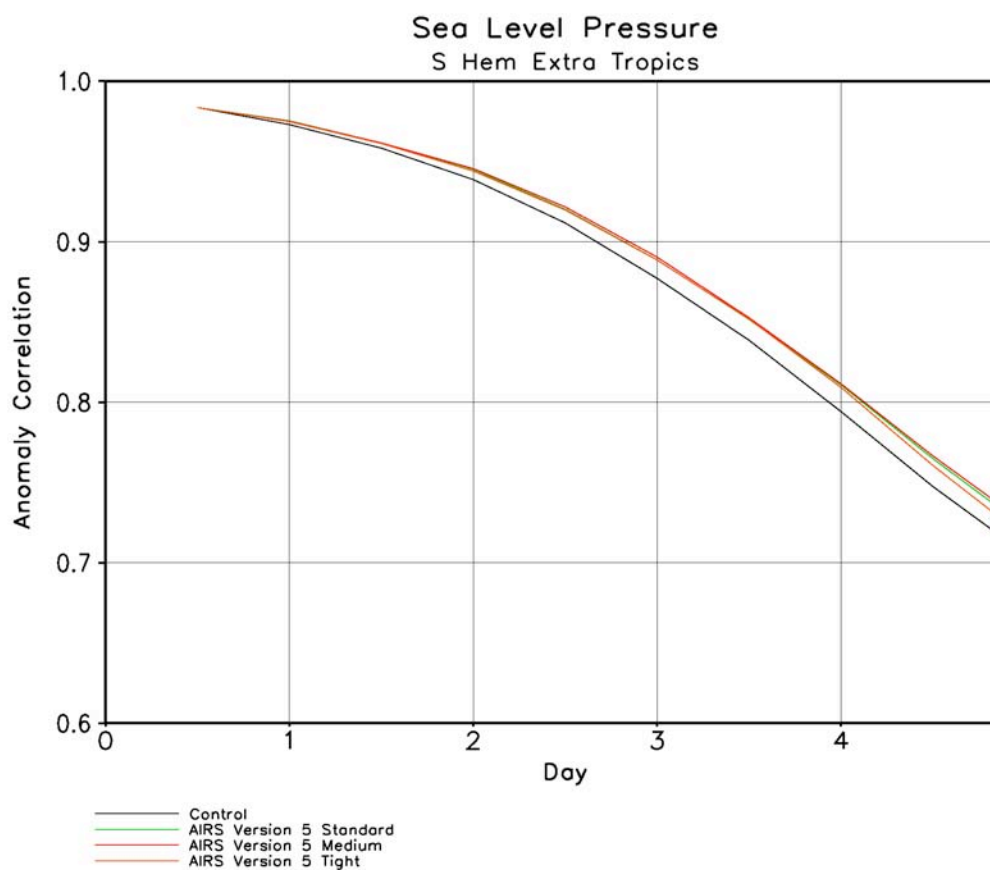
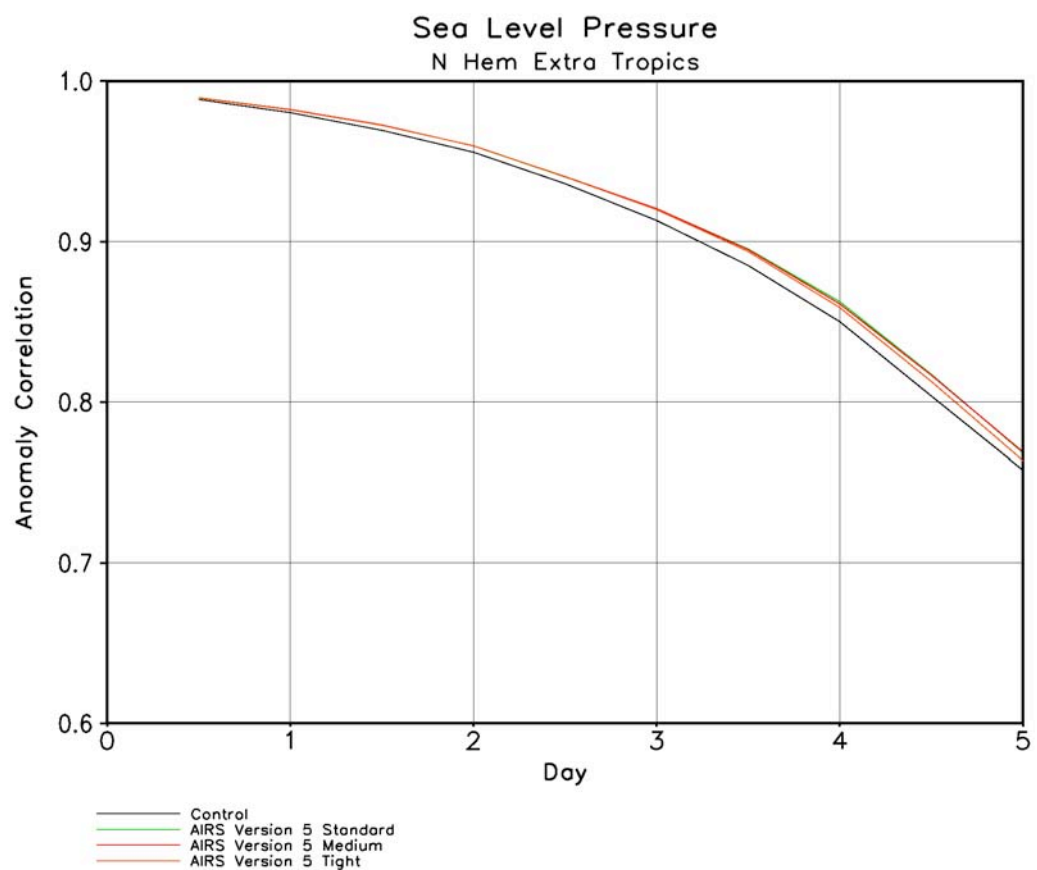
Experiment 1: Assessment of Trade-Off of Spatial Coverage and Overall Accuracy

We compared forecasts from four assimilations

- 1a Control
- 1b AIRS V5 Standard QC
- 1c AIRS V5 Medium QC
- 1d AIRS V5 Tight QC

AIRS temperatures are assimilated down to p_g

Data assimilated in all three AIRS experiments is otherwise identical, except for computation of p_g



Findings of Experiment 1

All three AIRS data assimilation experiments improved forecast skill significantly compared to the control

Northern hemisphere extra-tropics improvement in 5 day forecast skill

3 hours for Tight QC, 5 hours for Medium QC and Standard QC

Southern hemisphere extra-tropics improvement in 5 day forecast skill

4 hours for Tight QC, 6 hours for Medium QC and Standard QC

Medium QC performed slightly better than Standard QC, which was optimized for climate

Tight QC lost substantial impact as a result of reduced spatial coverage

We are performing more experiments to find optimal trade of accuracy and coverage for data assimilation

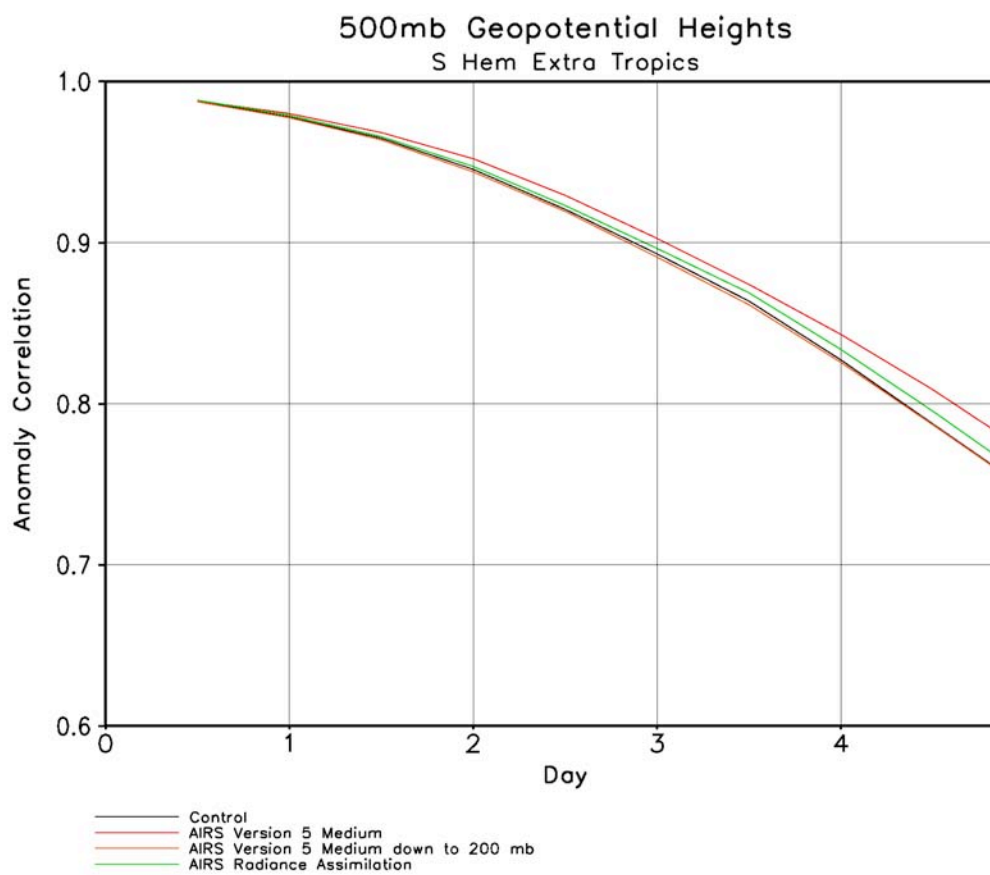
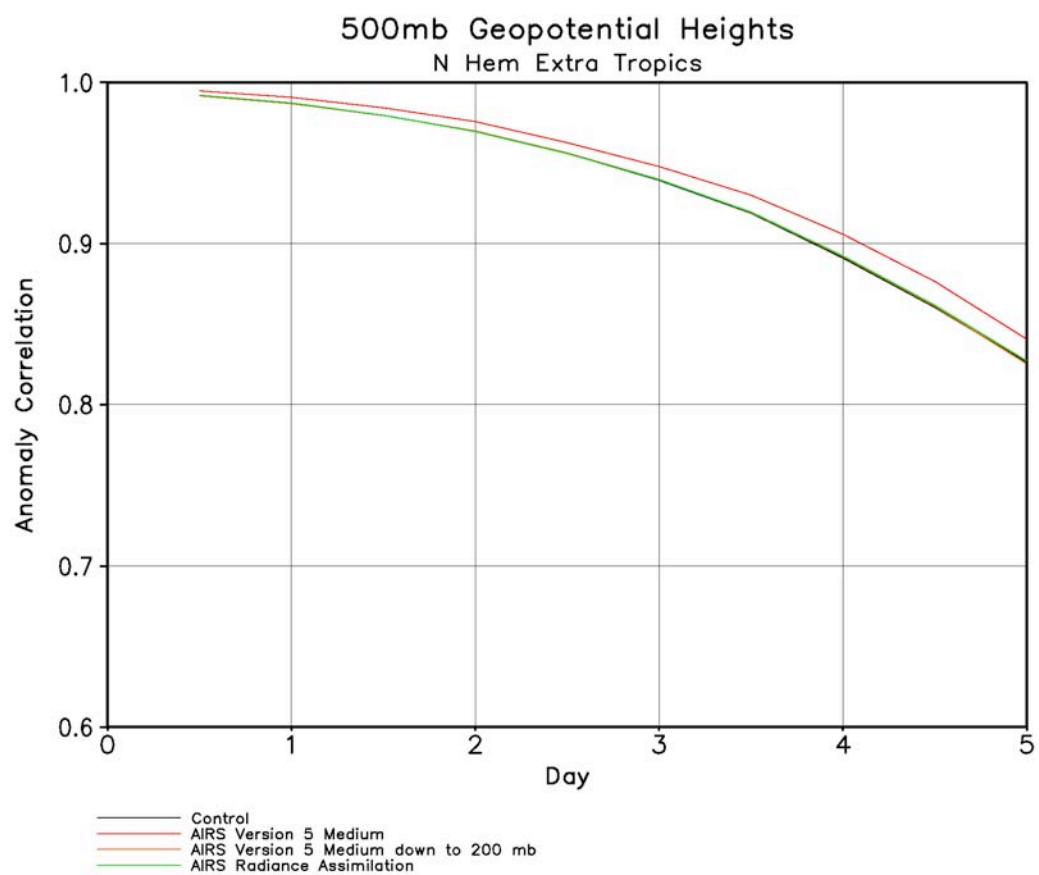
Experiment 2: Test of The Importance of Assimilation of Tropospheric Temperatures

Motivation

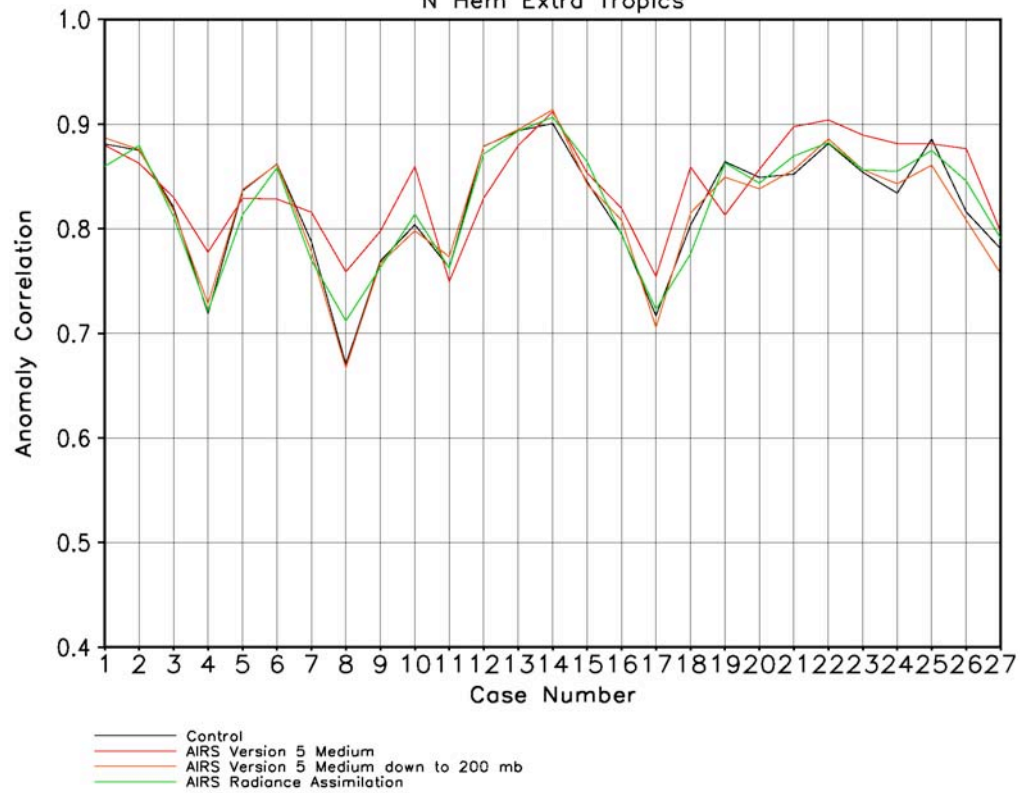
Tony McNally at ECMWF stated that most of the impact of AIRS radiances on ECMWF analysis comes from 15 μ m stratospheric sounding channels-claims only stratospheric information is important

We compared forecasts from four assimilations

- 2a Control – same as 1a
- 2b AIRS V5 Medium QC – same as 1c
- 2c AIRS V5 Medium QC but only down to 200 mb
- 2d AIRS radiance assimilation – uses primarily stratospheric AIRS radiance information
Assimilates only radiances unaffected by clouds



500mb Geopotential Heights
N Hem Extra Tropics



500mb Geopotential Heights
S Hem Extra Tropics



Findings of Experiment 2

Assimilation of AIRS temperature soundings only down to 200 mb (2c) produced no forecast impact

Most important information is coming from tropospheric temperatures in partial cloud cover

Assimilation of AIRS radiances unaffected by clouds (2d) was only slightly better than (2c)

AIRS cloud free radiances contain some tropospheric information - but is sub-optimal

Assimilation of AIRS radiances should perform better than operational procedure if

- 1) Use \hat{R}_i , together with error estimates
- 2) Do not use water vapor or ozone channels

Assimilation of these radiances makes problem highly non-linear

Positive impacts shown when we assimilated only AIRS T(p)

- 3) Make better use of AIRS 4.2 μm channels - day and night

- Perform surface parameter retrieval step before assimilation step to obtain T_s, ϵ_i, ρ_i

Allows for use of lower tropospheric sounding 4.2 μm channels

- Install new RTA that accounts for non-LTE so all 4.2 μm channels can be used

We will try experiments doing 1) and 2) in the near future

